Proceedings of the 29th Annual International
Conference of the IEEE EMBS
Cité Internationale, Lyon, France
August 23-26, 2007.

Development of Tilt Table with Visual Feedback Function for Hemiplegia Patients

Jongman Cho, *Member, IEEE* , Junghyeon Choi, Taewoo Nam, Junho Park, Inseon Park-Ko and F. Ibrahim, *Member, IEEE*

***Abstract*—Due to damaged vertebrae nerves, serious disease and aging, patients who have to lie down for long period of time need to exercise to maintain up-right standing position and recover their muscle power of paralytic leg. This study describes the development of an intelligent tilt table which can provide a patient with visual feedback of exercise to increase the effect of rehabilitation. This could be possible by measuring and displaying the knee bent angle and pressure for each foot during exercise in real time. It is expected that patient's exercising effect can increase by self-monitoring these two values during exercise.**

I. Introduction

ON this account of medical development, the number of saving human lives have increased and made longer. This fact kept pace with increasing rehabilitating patients. Due to damaged vertebrae nerves, serious disease and aging, patients who have to lie down for long period of time need to exercise to maintain up-right standing position and recover their muscle power of paralytic legs. But for these patients, staying in up-right standing position is such a difficult matter.

Therefore, a tilt table has been used in many rehabilitation hospitals to support patient's standing-up position for the course of rehabilitating program. However, this method has few problems. First one is that the tilting angle is adjusted by a manual way or simple electrical motor. Secondly, the medical doctors or physical therapists should stick with a patient to observe patient's physical condition and record the data. Therefore, patients can expect their time-efficiency and progressive rehabilitation if they can manage their leg-remedial-exercise by themselves with a real-time monitoring system.

The monitoring system proposed in this study collects knee bent angle (KBA) and load of each paralytic leg (LPL) during rehabilitation training. The collected data are analyzed and displayed on a patient monitor in real-time so that a rehabilitant can recognize and do his/her most suitable rehabilitation. It is expected that a patient will try to put more load on the paralytic leg during exercise by observing his/her real-time loading status for each foot and it will improve the training effect noticeably.

Jongman Cho is with the Department of Biomedical Engineering, Inje University, Gimhae, 621-749, Republic of Korea (corresponding author to provide phone: +82-55-320-3293; fax: +82-55-327-3292; e-mail: minerva@ieee.org).

Junghyeon Choi is with the Department of Biomedical Engineering, Inje University, Gimhae, 621-749, Republic of Korea (e-mail: cjh99@bse.inje.ac.kr).

Taewoo Nam is with the Department of Biomedical Engineering, Inje University, Gimhae, 621-749, Replublic of Korea (e-mail:ntw99@bse.inje.ac.kr)

Junho Park is with the Department of Biomedical Engineering, Inje University, Gimhae, 621-749, Republic of Korea (e-mail:pjh01@bse.inje.ac.kr)

Inseon Park-Ko is with the Parkside Rehabilitation Hospital, Busan, 608-812, Replublic of Korea (e-mail:pis@parkside.co.kr)

F. Ibrahim is with the Department of Biomedical Engineering, University of Malaya, Kuala Lumpur, 50603, Malaysia (e-mail:fatimah@um.edu.my)

II. Methods

A. Control of a tilt table

An electro-mechanical cylinder has been widely used for controlling tilting angle of a tilt table so far because it is low price and simple to control. However, it is easy to break down if tilting operation is occurred frequently and a tilt table is overloaded. It was proven that an oil-hydraulic cylinder driven by AC motor is used to overcome this problem. It was proven that an oil-hydraulic cylinder was easy to control tilting speed and get accurate tilting angle of a tilt table.

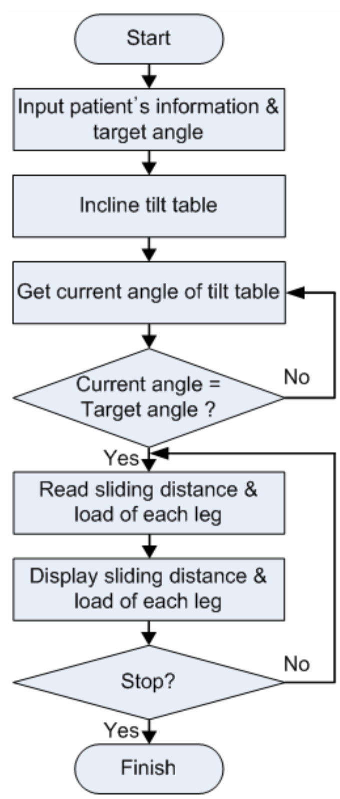


Fig. 1. Flowchart for the controlling process of the proposed tilt table with visual feedback function.

1-4244-0788-5/07/$20.00 ©2007 IEEE

The microcontroller resided in the control unit starts the AC motor of an oil-hydraulic cylinder until the tilt table reaches preset target tilting angle value. Figure 1 shows a flow for the entire controlling process for the proposed tilt table and figure 2 depicts the developed system consisting of a tilt table which is controlled by an oil-hydraulic cylinder and patient monitor displaying KBA and LPL simultaneously on patient monitor.

B. *Measurement of tilting angle*

Figure 3 shows a functional block diagram for the control unit of the developed system. The incremental inclinometer (T2, USdigital Inc.) and 24-bit multi-mode counter were used to measure tilting angle and it provides 3600 codes/revolution and the measured angle value is transmitted to a PC via a RS-232 serial interface.

Fig. 2. Developed tilt table consisting of feedback system.

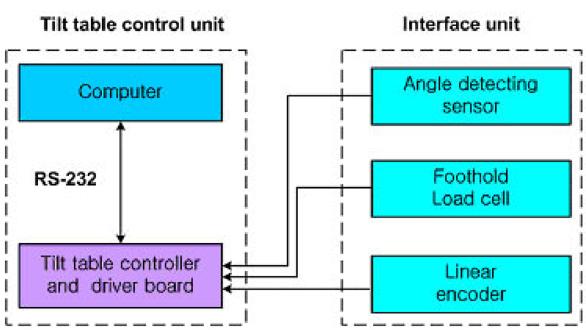


Fig. 3. Functional block diagram of the developed tilt table control unit.

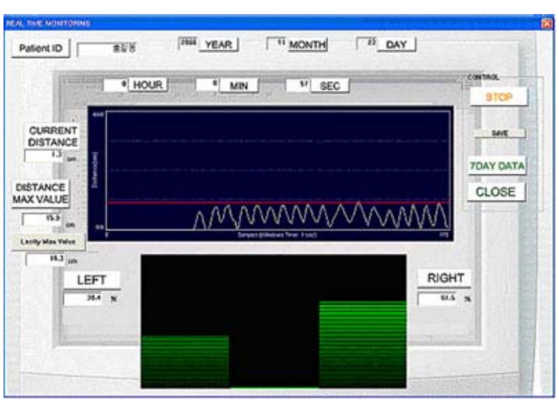


Fig. 4. Screenshot of the implemented feedback software

C. *Estimation of KBA*

The KBA is estimated indirectly by measuring the moving distance of the sliding table and a linear encoder which has 0.1mm resolution was used for measuring the distance. The linear encoder consists of linear strip marked 0.05mm and LED lenses. The output pulses of the linear encoder are counted by 24-bit multi-mode counter and the actual distance is sent to PC where it is displaced on the patient monitor.

D. *Measurement of LPL*

A load cell with 0.5g resolution is mounted on the each foothold to measure load (foot pressure) of rehabilitant's paralytic leg during exercise. The output of each load cell is filtered, amplified, converted into digital form by an angle-to-digital converter (MCP 3202, Microchip technology Inc.), and sent to PC for display on the patient monitor with KBA.

E. *Visual feedback through monitoring software*

An application program of monitoring system is implemented using Microsoft C++ 6.0 and it is running on a PC with Windows XP OS system, Pentium 4 and 1GB RAM. The KBA and LPL data were obtained from the control unit via RS-232C serial interface and theses data are stored on disk and displayed on the patients monitor at the same time. Figure 4 shows the screenshot of the implemented feedback system software.

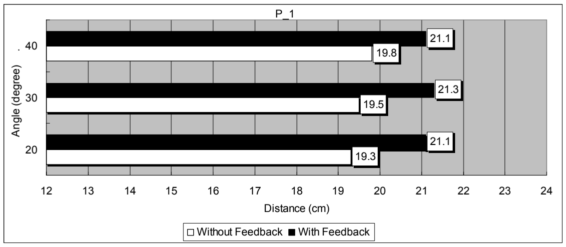
III. RESULTS

The developed system was experimented with six patients and each patient was requested to try two times of knee bent for each of 20, 30 and 40 degree of tilting angle – the first trial was done without visual feedback and the second trial was done with visual feedback through the patient monitor. Figure 5 (a) through (f) show KBA values for six patients. The sliding distance and KBA could not be measured over 40 degree because of injury consciousness.

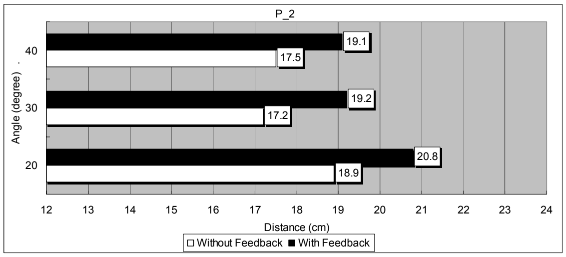
Figure 6 (a) through (f) shows average LPL rate, the percentage of the load for paralytic leg, when the feedback system was used and when it was not used.

IV. DISCUSSION & FUTURE WORK

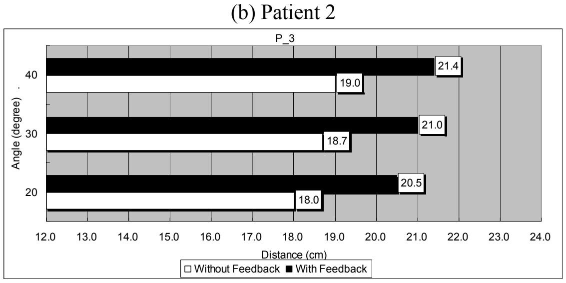
This study shows the feedback system which can provides a patient with status of the rehabilitation movement. The results showed that the feedback system gives good effects in the rehabilitation exercise. The paralytic leg bent degree of knee and load rate can be improved by using this visual feedback system. In addition, it can provide rehabilitants with the recognition of their movement and customized training. Also, it allows medical doctors to plan the efficient treatment for each patient. However, the KBA was not measured directly but estimated indirectly by measuring the moving distance of the sliding table. The direct measurement of KBA will provide more accurate information for treatment.



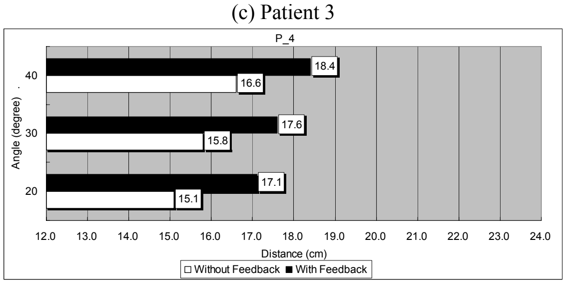
(a) Patient 1



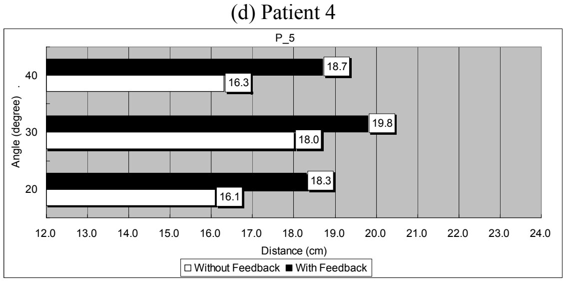
(b) Patient 2



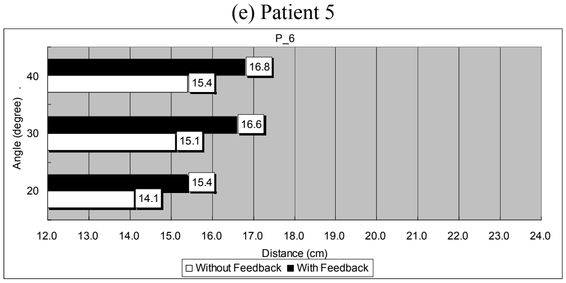
(c) Patient 3



(d) Patient 4

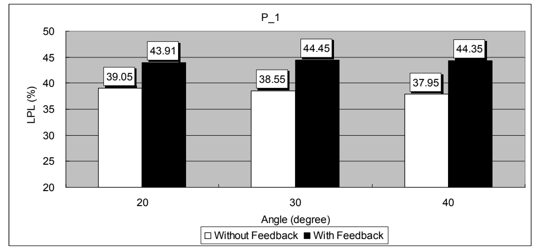


(e) Patient 5

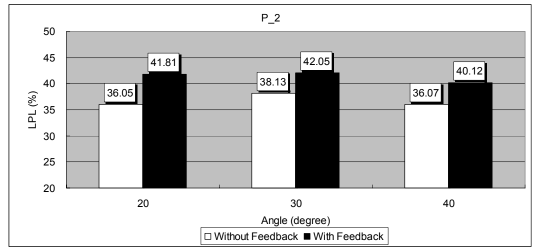


(f) Patient 6

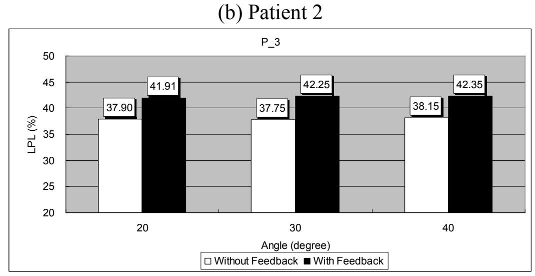
Fig. 5. The sliding distances (SD) for six patients. The white-colored bar indicates the SD without visual feedback while black-colored bar shows the SD when the visual feedback function was used through the patient monitor.



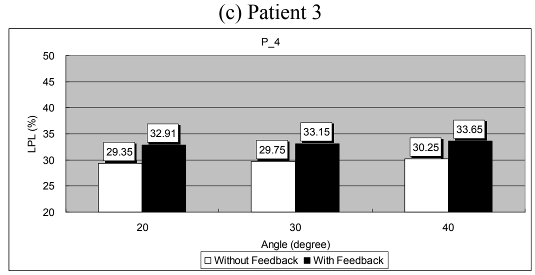
(a) Patient 1



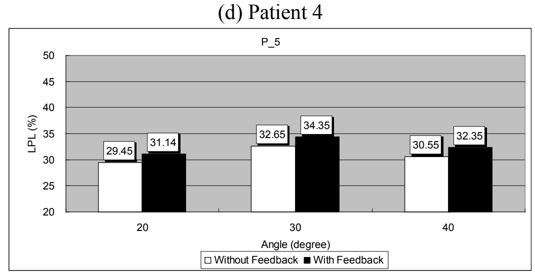
(b) Patient 2



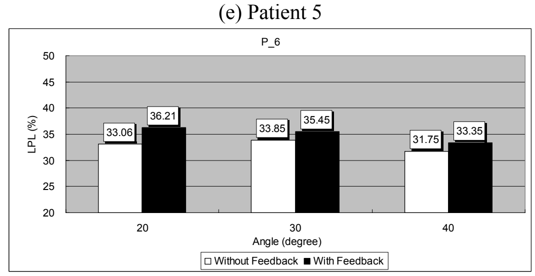
(c) Patient 3



(d) Patient 4



(e) Patient 5



(f) Patient 6

Fig. 6. The LPL rates for six patients. The white-colored bar indicates the LPL rate without visual feedback while black-colored bar shows the LPL rate when the visual feedback function was used through the patient monitor.

REFERENCES

[1] Jung Hee Oh, "Rehabilitation medicine", Dae Hak Seo Rim, 1997, pp. 268-269

[2] Olaf Oldenberg, MD et al, "Ambulatory Norepinephine Treatment of Severe Autonomic Orthostatic Hypotension", Ingernational journal of cardiology, 52, pp. 85-88

[3] S.W. Parry, R.A. Kenny, "Tilt table testing in the diagnosis of unexplained syscope", Q J Med, 92, 1999, pp. 623-629

[4] Lee, Hea Young, R.N, "Biomechanical Analysis on the Shift of Gravity Line in Hemiplegic Patients.", The journal of Korean society of physical therapy, 11, 1999, pp. 63-70

[5] "Tilt Table Study", Community Healthcare Inc., 2001, pe-cvi 900-12-21

[6] Jung-gyn Yoon, Myung-hoon Kim, Dong-won Yook, "The Effect of Self-Controlled Learing on Balance in Hemiplegics", PTK 12, 2005

[7] Kapandji IA, "The physiology of the joints", 4th Ed., Churchill Livingstone, 1982

[8] Davies PM, "Right in the middle selective trunk activity in the treatment of adult hemiplegia", Springer-Verlag, 1990

[9] Charness A., "Stroke Head Injury", Aspen Publisher, 1986

[10] Ryerson S & Levit K., "Functional movement reeducation", Churchill Livingstone, 1997